3.5 ECM NOISE ON-BOARD

Barrage noise jamming spreads a noise-like jamming signal over a frequency bandwidth to obscure all target returns. The jamming signal bandwidth must meet or exceed the bandwidth of the threat radar. Spreading the jammer power over a larger bandwidth decreases the overall effectiveness as the required signal bandwidth increases (fewer watts per megahertz). The jamming signal may also be modulated with an AM signal to create a more random noise signal.

Subroutine NOISE in *RADGUNS* simulates a barrage noise jammer whose signal may be amplitude modulated. The barrage noise jammer power signal is calculated at the threat radar antenna. The jammer output power is calculated by multiplying the barrage noise jammer power by the jammer transmitter antenna gain, taking a one-way path loss into account. This result is stored in the signal environment array along with the barrage noise signal return time and jammer frequency. Bandwidth effects are accounted for by multiplying by the ratio of the threat radar bandwidth to the jammer signal bandwidth.

The user must specify the nominal jammer transmitter power level (i.e., the power output when no modulation is applied), maximum transmitter power level, jammer transmit antenna gain, receive antenna gain, center frequency, bandwidth, J/S ratio for jamming effectiveness, percentage of modulation and the period of the modulation. Jamming will be sinusoidally adjusted if a non-zero modulation percentage is set in the input parameters. A 100 percent modulation will lead to a peak power output that is four times the nominal output without modulation. If the modulation percentage exceeds 100, the modulation waveform will be clipped on the bottom, and clipped on the top when the maximum jammer power is exceeded.

Data Items Required

Because the jammer is located on-board the target aircraft, the target position and velocity requirements for the Flight Path FE apply to this FE in addition to the following requirements:

Data Item		Accuracy	Sample Rate	Comments
1.3.1.1.1	Jammer power		SV/T	
1.3.1.1.2	Jammer bandwidth		SV/T	
1.3.1.1.3	Target signal		SV/T	
1.3.1.1.4	Jammer signal		SV/T	
1.3.1.1.5	Burn-through range		SV/T	
1.3.1.1.6	Jammer antenna gain		1 deg Az by 1 deg El/step	
1.3.1.1.7	Jammer angle		10 Hz	
1.3.1.1.8	Detection time		SV/T	
1.3.1.1.9	Time amplitude modulation		10 Hz	10 s intervals
1.3.1.1.10	Frequency		10 Hz	10 s intervals
1.3.1.1.12	Phase		10 Hz	
1.3.1.1.13	Angle error		10 Hz	
1.3.1.1.14	Range error		10 Hz	

3.5.1 Objectives and Procedures

The on-board noise jamming function is sensitive to changes in both target RCS and jammer transmit power level. To determine the effect of target RCS and jammer power on noise jamming, *RADGUNS* was executed with the following input conditions:

a.	Model mode:	SNGL/RADR
b.	Target RCS:	0.1, 0.9, 1.0, 1.1, 10.0 m^2
c.	Target altitude:	1000 m
d.	Flight path:	LINEAR
e.	Guns:	Disabled
f.	Jammer type:	On-board NOI
g.	Jammer power:	0.1 to 10.0 W
h.	Jammer antenna gain:	10 dB
i.	Jammer bandwidth:	Radar receiver bandwidth
j.	Output:	S/N ratio and burn-through range

3.5.2 Results

Figure 3.5-1 shows target and jammer signal powers at the radar receiver versus range for a 1.0-m^2 target and a 1.0-W jammer. Both signals increase as the target and jammer approach the radar receiver. The burn-through range (range at which the target signal exceeds both the detection threshold and the jammer signal) is 2815 m.

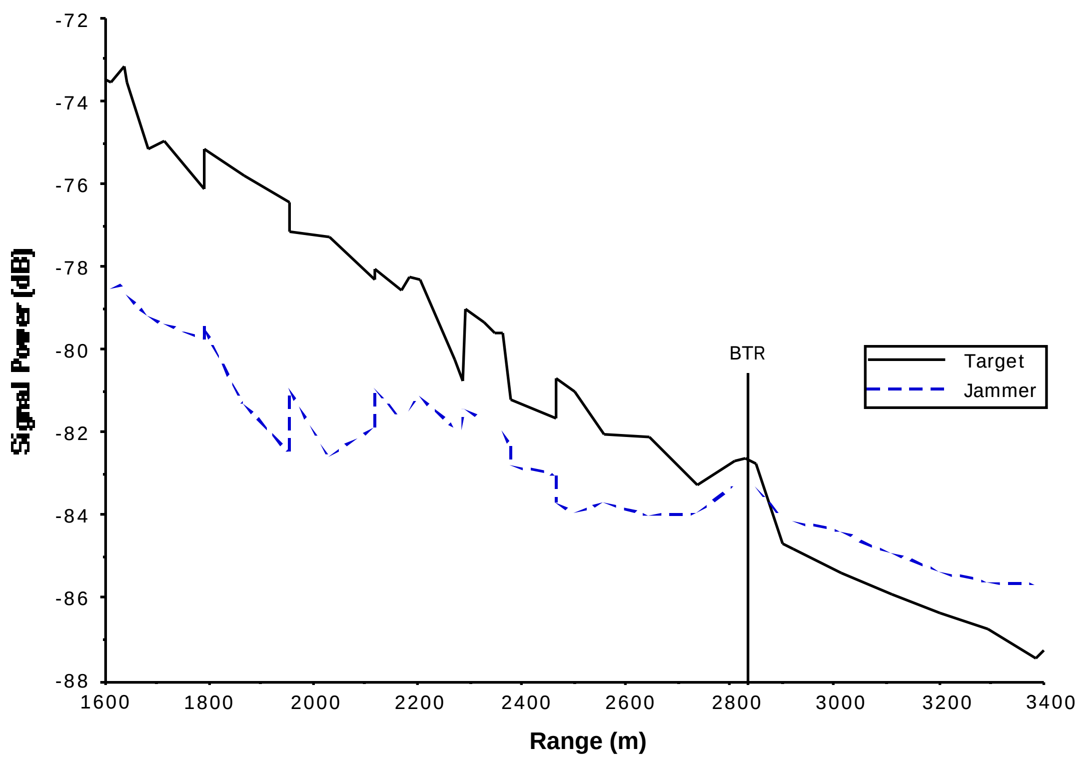

FIGURE 3.5-1. Burn-through Range for a 1.0-m^2 Target with a 1.0-W Jammer.

The burn-through range for a 10.0-m^2 target and a 10.0-W jammer is 2795 m. Thus, an increase in both target RCS and jammer transmit power by the same order of magnitude causes little effect on burn-through range (20 m). The target and jammer signals at the receiver increase linearly with the increase in RCS and jammer power (10 dB).

Figure 3.5-2 shows the effect of jammer power on range tracking error. The spikes are range track break locks followed by attempts to reacquire the target. For a 1.0-m^2 target, a 0.1-W jammer has little or no effect on range tracking error. A 1.0-W jammer, however, causes the tracker to break lock until the target reaches the burn-through range (43 s). The tracker again breaks lock after the target crosses over the radar (50 s) and the target moves out of range. A 10-W jammer completely obscures the target return causing break locks for the duration of the engagement.

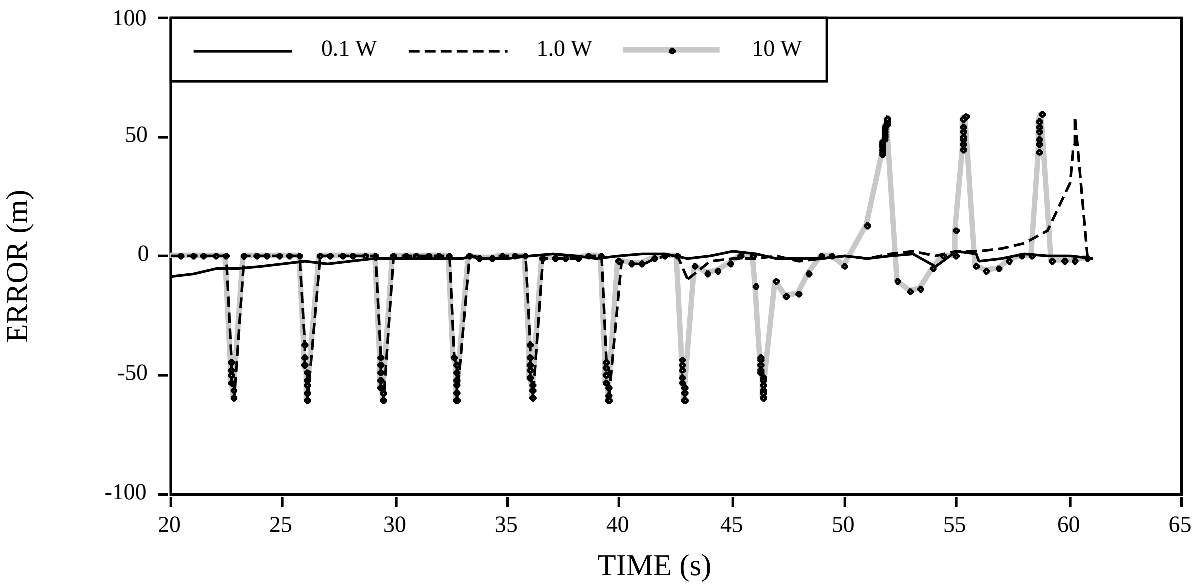

FIGURE 3.5-2. Effect of Jammer Power on Range Tracking Errors.

Figure 3.5-3 shows the effect of target RCS and jammer power on burn-through range. The RCS curve was obtained by varying target RCS while maintaining a constant 1.0-W jammer power. Similarly, the jammer power curve was obtained with a constant 1.0-m^2 RCS. In both cases, a 10% variation in either target RCS or jammer power results in approximately a 5% variation in burn-through range. These results are tabulated below in Tables 3.5-1 through 3.5-3.

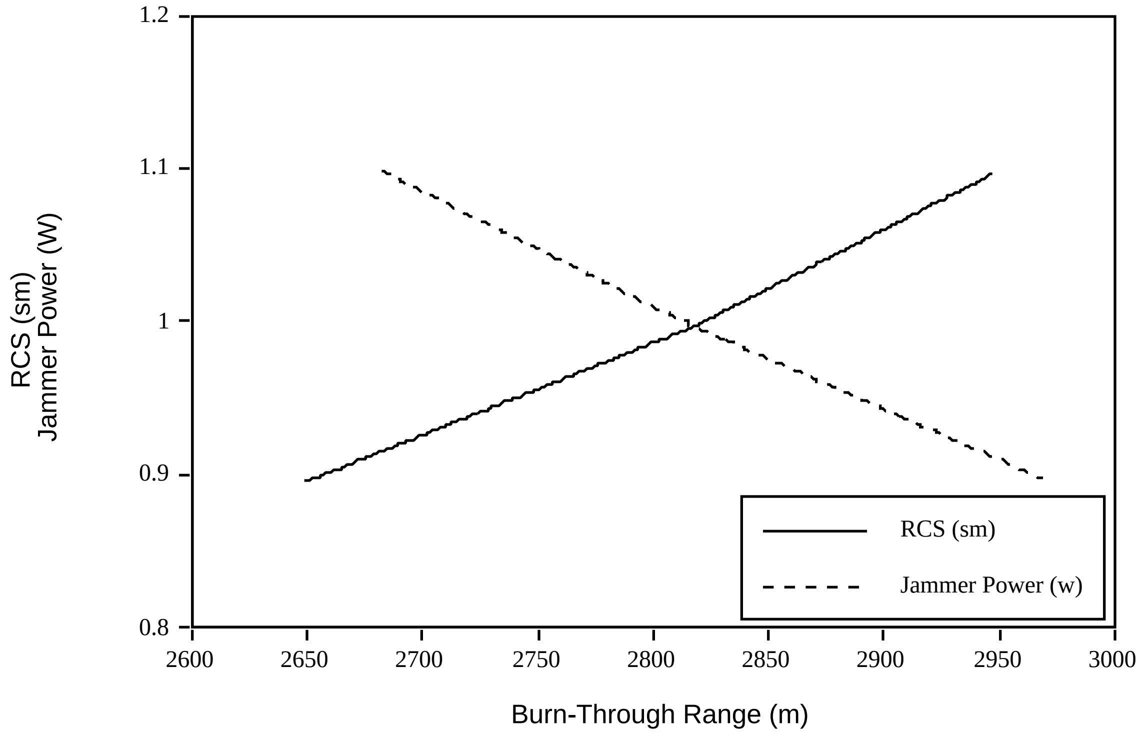

FIGURE 3.5-3. Effect of Target RCS and Jammer Power on Burn-Through Range.

TABLE 3.5-1. Target Effect on Burn-Through Range.

RCS (m^2)	**ÆBTR (m)**	**%var RCS %var BTR**
0.1	2078	90 74
0.9	164	10 5.8
1.0		
1.1		
10.0		

TABLE 3.5-2. Jammer Effect on Burn-Through Range.

JxP (W)	**ÆBTR (m)**	**%var RCS %var BTR**
0.1		90
0.9		10
1.0		
1.1	131	4.7
10.0	1925	68

TABLE 3.5-3. Jammer Power Effects on Burn-Through Range for a 1.0-m^2 RCS Target.

Jammer Power (W)	% Power from Nominal	Burn-Through Range (m)	% Variation from Nominal
0.5		3595	+19
0.9		3030	+0.7
1.0	- 0 -	3010	- 0 -
1.1	+10	2900	
1.5	+50	2398	

3.5.3 Conclusions

The jammer-to-signal ratio is defined as:

$$\frac{J}{S} = \left(\frac{P_j B G_j}{P_r G_r}\right)\left(\frac{4\pi}{\sigma}\right)\left(R^2\right) \qquad [3.5\text{-}1]$$

where:
- J = jammer noise power
- S = echo power
- P_j = jammer power density
- B = radar receiver bandwidth
- G_j = jammer antenna gain
- P_r = radar power
- G_r = radar antenna gain
- s = target RCS
- R = range

If $(J/S)_{min}$ is defined as the minimum J/S ratio that will just barely conceal the echo in the noise and Equation [3.5-1] is solved for R_B (burn-through range):

$$R_B = \left[\frac{P_r G_r \sigma (J/S)_{min}}{P_j B G_j 4\pi}\right]^{\frac{1}{2}} \qquad [3.5\text{-}2]$$

Thus, the burn-through range varies inversely as the square root of the jammer power P_j as shown in Figure 3.5-4.

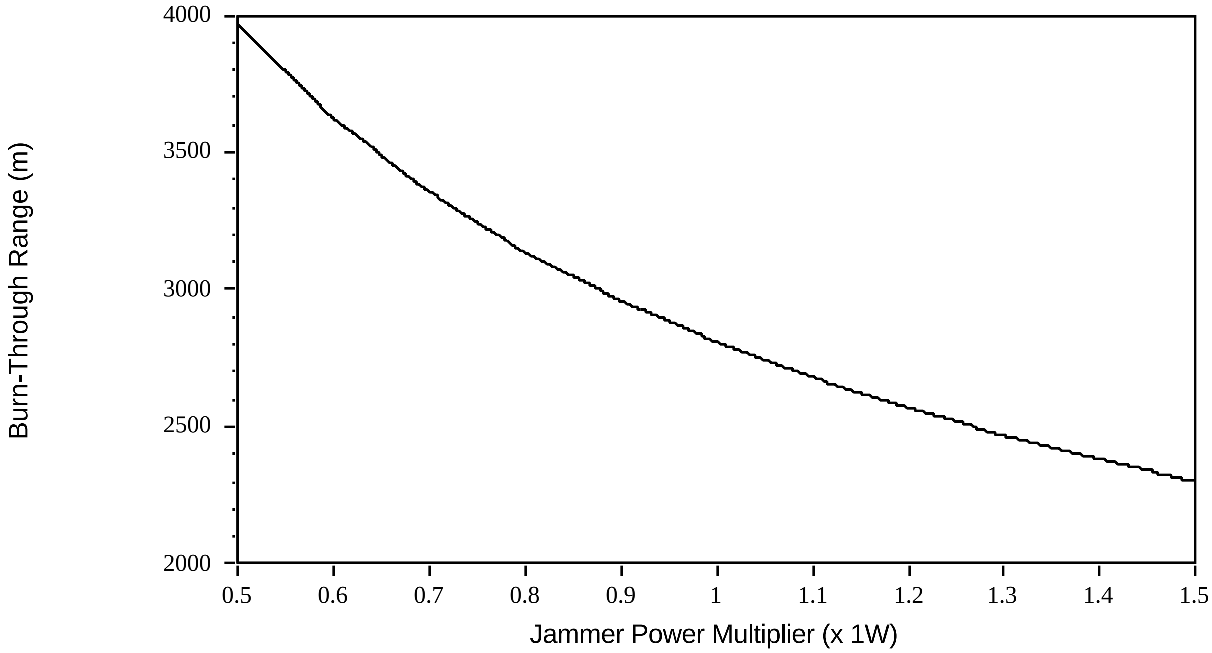

FIGURE 3.5-4. Jammer Power Effects on Burn-Through Range for a 1.0-m^2 RCS Target.